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An analysis of the United States renal transplant patient population and organ survival characteristics: 1977 to 1980

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An analysis of the United States renal transplant patient population and organ survival characteristics: 1977 to 1980. This study examines the relationship between renal transplant organ survival and the extent of HLA (human leukocyte antigen) A and B loci antigen matching. Combined dialysis and transplant records for patients in the End Stage Renal Disease Medical Information System (ESRD MIS), 1977 to 1980, were analyzed to examine transplant organ survival characteristics and changes in demographic pattern and donor types compared to previously reported studies of the United States transplant patients. Actuarial survival curves for high match (3 or 4 HLA A and B loci antigen matches) versus low match (0, 1, or 2 HLA A and B loci antigen matches) groups were analyzed for their relative difference and its statistical significance. In addition, this relationship was analyzed with controls for age, sex, race, mixed lymphocyte culture (MLC), crossmatch, and prior time on dialysis. For both cadaver and living related donor transplants, statistically significant differences were found between the survival curves of high and low match groups. Comparing low match and high match groups, there were differences in 1-year organ survival of 4.8 and 11.3%, respectively, for cadaver and living related donor transplants. MLC negative and crossmatch positive status appear to improve transplant organ survival beyond the effects of HLA matching. The study also designates several methodological problems inherent in transplant organ survival studies including: whether or not to include patient deaths as therapeutic failures, and whether or not to analyze transplant organ survival at one point in time or to compare overall survival curves for the entire study period.

Analyse des caracteristiques de la population de malades transplantes renaux et de la survie d'organes aux etats-unis: 1977 à 1980. Cette étude examine la relation entre la survie de reins de transplantés et l'importance de la compatibilité HLA (antigène leucocytaire humain), pour les locus A et B. Les dossiers combinés de dialyse et de transplantation des malades du End Stage Renal Disease Medical Information System (ESRD MIS), de 1977 à 1980, ont été analysés pour examiner les caractéristiques de la survie des organes transplantés, et les modifications de l'aspect démographique et des types de donneurs par rapport aux études préalablement rapportées de malades transplantés aux Etats-Unis. Les courbes de survie actuarielles pour une forte compatibilité (compatibilité pour 3 ou 4 HLA A et B) par rapport à une faible compatibilité (0, 1 ou 2 HLA A et B) ont été analysées pour leur différence relative et leur signification statistique. En plus, cette relation a été analysée en contrôlant l'âge, le sexe, la race, les cultures mixtes de lymphocytes (MLC), les crossmatch, et la période de dialyse. Pour les transplants à partir de cadavres ou de donneurs vivants apparentés, des différences statistiquement significatives ont été trouvées entre les courbes de survie pour les groupes à forte ou à faible compatibilité HLA. Ce travail met en évidence certains problèmes méthodologiques inhérents aux études de survie des organes transplantés: faut-il ou non considérer les décès comme des échecs thérapeutiques et faut-il ou non analyser la survie de l'organe transplanté à un moment dans le temps ou comparer les courbes globales de survie pour la totalité de la période considérée.

The importance of HLA matching to cadaver transplant organ survival is considered unresolved by many researchers [1, 2]. This issue was addressed in 1975 by the American College of Surgeons (ACS 12th Report) utilizing a population consisting of United States, European, and Canadian transplant patients [3]. An improvement in transplant organ survival was found in the ACS 12th Report with better HLA matching (Table 1). Two other major retrospective studies based on predominantly United States transplant patients did not find a statistically significant difference among different levels of HLA matches in the transplant organ survival (Table 1) [4, 5].

None of these and other previous studies had the opportunity to analyze combined dialysis and transplant records on the same patients studied.

In 1977, the Health Care Financing Administration (HCFA) took responsibility for the acquisition and dissemination of information of United States transplant patients from the American College of Surgeons, National Transplant Registry. These data are in the End Stage Renal Disease Medical Information System data set which combines dialysis and transplant information on ESRD patients. In this study, the HCFA ESRD data set was used to describe the United States transplant population between 1977 and 1980. Through these data, the relationship of histocompatibility matching at the HLA A and B loci to transplant organ survival in living related and cadaver donor transplants was analyzed. Unfortunately, much information on renal transplants performed during the period of study (1977 to 1980) was not reported to the HCFA. Because patient death information was only partially reported to the ESRD MIS, this study limited its focus to organ survival. The patient survival aspect of the research cannot be addressed adequately in this study due to insufficient data.

The relationship between HLA matching and transplant organ survival was examined for the overall cadaver and living related transplant groups and for subgroups of patients with controls for age, sex, race, blood type, crossmatch, mixed

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Table 1. A comparison of HLA matching and cadaver donor first transplant organ survival in selected multicenter retrospective studies[a]

	Study			
	ACS 12th Report [1]	KTHS [3]	Opelz et al [5]	Current study
Data utilized	288 transplant centers, including 164 United States centers; number of states represented unknown.	43 United States transplant centers; number of states represented unknown.	145 United States and Canadian transplant centers; number of states represented unknown.	135 United States transplant centers; 39 states represented.
Data period	1951 to 1972	1974 to 1976	1970 to 1975	1977 to 1980
Sample patient size	1301	1533	4851	3671
Actuarial organ survival percent difference between "low" vs. "high" HLA A and B loci match at 1 year	10%	No statistically significant difference reported.	2%	5%
Controlling factors which improved the HLA matching and organ survival relationship	Not analyzed	Not analyzed	Male sex Non O blood type	MLC negative Crossmatch positive

[a] Estimate made from separate actuarial survival curves for 0, 1, 2, 3, and 4 matches.

lymphocyte culture (MLC), and prior time on dialysis. The demographic characteristics of the transplant population in the study were compared to previously reported transplant studies primarily based on United States transplant patients.

Two major methodological issues in evaluating transplant organ survival were addressed in this study. The first concerns the definition of organ survival, that is, whether patient deaths prior to redialysis should be included in the computation of actuarial life table percent organ survival. The second, whether organ survival results should be reported at one point in time or for the overall survival curves for the duration of the study period.

Methods

Patient selection. Unit records (defined as information on a particular patient relating to his dialysis and transplant therapy stored under one system-unique identifier) were obtained from the End Stage Renal Disease Medical Information System, HCFA, of the United States Department of Health and Human Services. The data set included approximately 102,000 ESRD patients treated by dialysis or transplantation (or both) during the period from January 1, 1977, through June 30, 1980. Of an estimated 12,000 renal transplants[1] that were performed during this period, 6366 with first transplants had HCFA tissue typing information forms available. From these, 3671 patients were included in our analysis. The remaining patients were excluded due to lack of: *(1)* two or more HLA antigens identified, *(2)* donor type, and *(3)* transplantation date.

Patients were divided into groups according to: *(1)* age, less than 15 years, 15 to 54 years, or greater than 55 years; *(2)* race, white or nonwhite (nonwhites included blacks, American Indians, and orientals); *(3)* blood type, O and non-O (non-O included types A, B, and AB); *(4)* MLC, positive and negative; *(5)* donor specific crossmatch, positive or negative; and *(6)* prior time on dialysis, 3 months or less or greater than 3 months of dialysis prior to transplantation. All information concerning HLA matching, donor specific crossmatch, and MLC reports were obtained from HCFA tissue typing forms. Information concerning the methods used to perform tissue typing, MLC testing and crossmatch used by the reporting centers was not available in the ESRD MIS. The definition of positive and negative MLC according to degree of MLC reactivity was also not available in the ESRD MIS. Crossmatch and mixed lymphocyte culture results were reported as positive, negative, not performed, or equivocal. Equivocal test results were excluded from our analysis. High match patients were defined as those patients with three or four matches at the HLA A and B loci. Low match patients were those with 0, 1, or 2 HLA A and B loci matches.

Computations. Transplant organ survival was calculated using the standard actuarial life table method [6]. Patient data were available by quarters (3-month periods). Graft organ survival time was defined as the interval between the date of transplantation and the beginning of dialysis therapy of two consecutive quarters, or longer, subsequent to date of transplantation. Actuarial survival curves were computed for living related and cadaver donor transplants for the overall high versus low match groups and for the subgroups as listed above. Low and high match organ survival curves for the 3-year period of analysis (1977 to 1980) were compared for their relative statistical difference utilizing the Wilcoxen-Breslow (WB) test statistics. This method compares the entire survival curves for high and low match groups and analyzes the probability that the two curves did not differ by chance.

Results

Description of study population. The ESRD MIS data set consisted of the pertinent patient information from 135 centers

[1] This figure was estimated from a tabulation of inpatient billing forms with a surgical procedure code for transplantation. Completeness and reliability of this record were not verified.

Table 2. Changes in transplant recipient race[a]

Year	Recipient race	
	% White	% Nonwhite
1971	87.1	12.9
1972	86.6	13.4
1973	84.2	15.8
1974	82.9	17.1
1977 to 1980	78.6	21.4

[a] Race data for 1971 to 1974 are based on the 13th Report of the Human Renal Transplant Registry by the American College of Surgeons [8], while 1977 to 1980 data are based on the current study.

Table 3. Changes in transplant donor type

Year	Donor type[a]	
	% Cadaver	% Living relative
1971	68.2	31.8
1972	67.3	32.5
1973	70.4	29.6
1974	NA[b]	NA
1977 to 1980	77.7	22.3

[a] Donor type data for 1971 to 1974 are based on the 12th Report of the Human Renal Transplant Registry by the American College of Surgeons [3], while 1977 to 1980 data are based on the current study.
[b] Not available.

Table 4. Percent not reported: By items of HCFA ESRD MIS transplant data set[a]

Data items	% Not reported
Donor type	12.6
Donor age	24
Donor sex	20.7
Donor race	22.5
Donor blood type	20.8
Recipient race	18.8
Recipient blood type	19.7
Crossmatch	19.2
MLC	25.7

[a] From the 6,366 patients with HCFA tissue typing forms available.

Table 5. Causes of death

Data items	*N*	%
Cardiac	26	22.4
Cerebrovascular	15	12.9
Pulmonary embolism	7	6.0
Hemorrhage (including GI)	13	11.2
Infection	44	38.0
Hyperkalemia	6	5.1
Pancreatitis	1	0.9
Malignancy	2	1.7
Withdrawal from dialysis	1	0.9
Suicide	1	0.9
Total	*116*	*100*

in 39 states. The race distribution of renal transplant recipients was 78.6% white and 21.4% nonwhite. The percentage distribution of nonwhite renal transplant recipients has increased progressively from 12.9% in 1971 to 21.4% in the present study (Table 2) [8]. The sex ratio of the renal transplant recipients in this study was 65% male, 35% female, which has not changed appreciably from the ratio reported in the 13th Report by the American College of Surgeons (62% male and 38% female) [8]. Ninety-six percent of the patients in this study were between the ages of 15 and 54, with approximately 2% each in the age groups less than 15 and greater than 55, and 0.4% were greater than 65 years of age. There was a progressive increase in the percentage of cadaver donor transplants from 68.2% in 1971 to 77.7% in the present study (Table 3) [3]. Among patients with HCFA ESRD MIS tissue typing forms submitted, 20% had one or more of the 11 data items missing (Table 4).

Causes of death. Among the 116 patients with causes of death reported, 44 (38%) were related to infection, and 41 (35%) were cardiovascular or cerebrovascular in origin (Table 5). These results, as well as the distribution of the causes of death, are similar to other reported studies [9, 10].

Effect of high versus low HLA A and B loci match on transplant organ survival

Cadaver donor transplants (Fig. 1 and Table 6). For cadaver donor transplants, the overall 3-year survival curves for high and low matches were statistically different from each other (WB = 3.8, $P < 0.05$). A statistically significant difference between high and low match curves was also indicated for MLC negative transplants. (It should be noted that MLC results are not usually reported for cadaver transplants, but 140 MLC reports were contained in the ESRD MIS.) White, female, and blood type 0 recipients also indicated a trend toward improvement in organ survival with better HLA matching (WB = 2.6, $P \leq 0.06$ for all three). Age and prior time on dialysis did not have a statistically significant effect on organ survival.

Living related donor transplants (Fig. 2 and Table 7). In living related donor transplants, the overall high and low match curves were statistically different from each other (WB = 18.00, $P < 0.00001$). The curves were also significantly different in MLC negative, crossmatch negative transplants, and in recipients of both blood types 0 and non-0, white and male recipients (WB = 4.0, $P < 0.05$). Females and nonwhites did not indicate a significant difference in high versus low match survival curves.

Actuarial percent survival difference at 1 year (Tables 6 and 7). The 1-year overall graft survivals for high and low match cadaver donor transplants were 68.4 and 63.5%, respectively, a difference of 4.8%. The percentages for living related transplants were 82 and 71%, respectively, a difference of 11%.

For both cadaver and live related donor transplants with reported negative MLC reaction, a higher percentage organ survival at 1 year was indicated for the high match group relative to the low match group with a difference of 29.9% in cadaver transplants and 13.8% in live related transplants. A similar result was seen for crossmatch positive cadaver transplants with a 56.3% difference in organ survival between high and low match groups, although the sample size was only 16. There were no living related transplants with positive crossmatch in the study population.

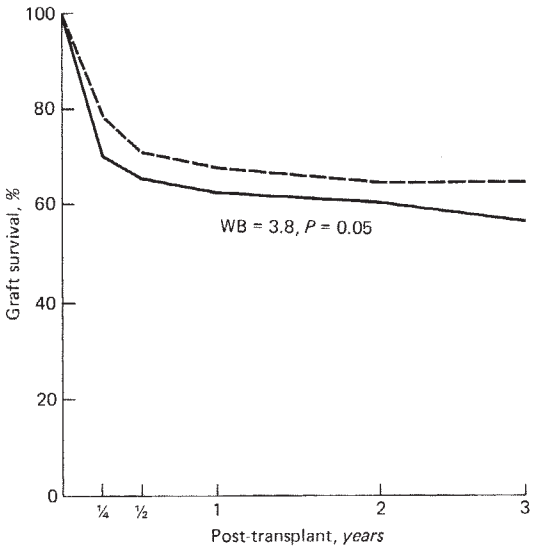

Fig. 1. *Actuarial percent survival for cadaver donor organ group.* Patients who died before redialysis were excluded. *N* equals 2743 (surviving organs = 1770; organ failure = 973). The *solid line* represents the low match group (0, 1, 2 matches). The *broken line* represents the high match group (3, 4 matches).

For both cadaver and live related donor transplants with positive MLC reactions a lower percent organ survival was indicated for the high match group relative to the low match group with a difference in percent survival at 1 year of 44.8% in cadaver transplants and 6.8% in live related transplants.

Discussion

The data utilized in this study has several limitations. First, out of the estimated 12,000 transplants performed during the study period, only 30% (approximately) of the patients were included in this study, due to incomplete reporting.

The study population may not be a random sample of the total transplant population for this period. Thus, the inferences made in this study may not be valid for the total United States transplant population. Another limitation of the ESRD MIS data is that only a small proportion of patient death is reported. Therefore, analysis of patient survival could not be performed. Completeness of reporting has been a major problem with the ESRD MIS and the motivation for completing the HCFA forms has been financial. Reporting of deaths is not necessary for reimbursement for ESRD services and is the presumed reason for the low rate of patient death reporting. On the other hand, reporting of the return of a transplant patient to dialysis was substantially more accurate since receipt of this information by HCFA was required for reimbursement. Thirdly, those patients whose record was complete enough to be included in this study may have had incorrectly reported information. For example, a positive donor-specific crossmatch is usually an absolute contraindication to the performance of a renal transplant. Nevertheless, 16 such patients were contained in the data set. Similarly, while most institutions would not perform a MLC positive live related donor transplant, 102 such patients existed in the data we analyzed.

For those patients whose HLA tissue typing, MLC reactions, and crossmatch status were recorded on the HCFA tissue typing form, information concerning the methods used to perform these tests was not available. Thus, the degrees of uniformity in test procedures could not be verified. Therefore, the resulting information reported to the ESRD MIS is suspect in its reliability.

Despite these limitations, this analysis, to our knowledge, is the first summary of the United States national transplant experience since the termination of the American College of Surgeons' Renal Transplant Registry in 1976. In addition, although the study population might not be the random sample of the total United States transplant patient population for the study period, it is composed of patients from 39 states and 134 centers. Thus, it may well be considered representative in many respects. Also, the ESRD MIS contains combined dialysis and transplant records. Thus, return of a transplant patient to dialysis could be determined reliably.

The 12th and 13th Reports based on by the Transplant Registry of the American College of Surgeons, included European and Canadian transplantations in addition to the United States transplantation data. Our study was based exclusively upon United States transplantations and may not be fully comparable. Nevertheless, one can see a trend of increase in the percentage of nonwhite renal transplant recipients and cadaver donor transplants from 1971 to the present study. The 9.1% increase in the proportion of nonwhite recipients may correspond to the 9.5% increase in the proportion of cadaver donor recipients (Tables 2 and 3), and may reflect the fact that 87% of the transplants performed in nonwhites were from cadaver donors. Only 4% of the transplant patients were less than 15 years of age or older than 55. The number of transplants with adequate completeness of reported data in this study was approximately 30% of the total estimated transplants performed during the period of the study (1977 through 1980). This compares favorably to the 12th Report by the American College of Surgeons, in which approximately 24% of the first transplants reported to the Registry had tissue typing information available for analysis.

The results of this study indicate that HLA matching improves transplant organ survival in live related donors as well as cadaver donor transplants. The latter result has not been reported in many transplant studies. Nevertheless, three out of four large multicenter retrospective studies, based largely on United States transplant population data, indicate improvement in cadaver transplant organ survival with better HLA matching (Table 1). Extrapolations from those studies show results similar to ours for cadaver donor organ transplants, with a range of 2 to 10% larger 1-year graft survival of high match groups comparing to low match groups. In this study, larger 1-year graft survival percents of 4.8 in cadaver transplants and 11.3% in living related transplants were indicated for high match groups comparing to low match groups.

Although it is convenient to talk about graft survival at 1 year or at any given point in time, we chose to analyze organ survival by comparing the difference between the entire 3-year survival curves for high versus low match groups. The rationale for this is the differences between the high and low match group curves at each time interval are uneven. For example, the largest differences between the survival curves occurred during the

Table 6. Acturial percent survival—cadaver donor organs

Controlling factors	Survival time for low and high matches					N^b	Wilcoxon/Breslow test statistic[a]	P value[a,b]
	3 Months	6 Months	1 Year	2 Years	3 Years			
Overall								
% Survival for low match	74.9	68.0	63.6	60.0	57.1	2743	3.82	0.03
% Survival for high match	77.2	72.3	68.4	65.6	65.6			
Crossmatch (−)								
% Survival for low match	75.2	69.0	64.0	60.4	57.4	2670	3.10	0.04
% Survival for high match	78.9	72.6	68.5	65.6	65.6			
Crossmatch (+)								
% Survival for low match	80.0	60.0	25.5	12.7	—	16	2.90	0.05
% Survival for high match	100.0	81.8	81.8	81.8				
MLC (−)								
% Survival for low match	74.1	68.2	61.0	56.1	56.1	81	2.90	0.05
% Survival for high match	90.9	90.9	90.9	90.9				
MLC (+)								
% Survival for low match	80.0	72.0	69.4	69.4	69.4	59	1.90	—
% Survival for high match	50.0	50.0	25.0	—	—			
Recipient blood type (type O)								
% Survival for low match	75.6	68.9	64.7	59.5	56.8	1207	2.60	0.06
% Survival for high match	82.5	74.3	70.9	68.5	68.5			
Recipient blood type (non O)								
% Survival for low match	74.6	67.3	63.0	60.7	57.4	1507	1.05	0.15
% Survival for high match	76.4	72.4	66.1	62.9	58.6			
Recipient race (white)								
% Survival for low match	76.2	71.3	67.3	58.3	53.7	612	2.57	0.06
% Survival for high match	84.3	77.3	72.9	72.9	72.9			
Recipient race (nonwhite)								
% Survival for low match	74.9	66.4	63.8	55.3	48.6	224	0.42	0.26
% Survival for high match	63.0	63.0	57.2	57.2	57.2			

Abbreviation: MLC, mixed lymphocyte culture.

[a] Wilcoxon-Breslow (WB) test statistics analyze the statistical significance concerning the relative differences between the curves; a one-tail P value is reported for the statistical significance of the given WB. A WB test value greater than 3.8 and P value for each of less than 0.05 is considered statistically significant. Subgroup numbers are smaller than overall group numbers since they include data for the controlling factors as well as for a HLA match.

[b] Both N and P values apply to high and low matches.

first 6 to 12 months (Tables 6 and 7), with much less difference after 1 year. Therefore, analysis of survival at one point in time may result in either an overestimation or underestimation of the overall differences in organ survival between high and low match groups. For example, in Table 6, the percentage survival difference at 3 months for the overall cadaver group was 2.3%, a relatively small difference, while the entire survival curves are substantially different. In this study, percent survival at various points in time is reported for comparison purposes with other studies. Moreover, selection of a single time point is arbitrary and allows for investigator bias to effect comparisons.

The 1-year graft survival for cadaver donor transplants was approximately 10% higher in our study than those in Table 1. These higher values are due to our definition of graft failure, which excluded deaths prior to redialysis. Two studies that excluded deaths (with a functioning kidney), for the calculation of graft survival respectively found 10 and 19% higher 1-year organ survival when deaths were excluded than when they included deaths prior to patient's return to dialysis [11, 12].

The exclusion of deaths prior to a transplant patient's return to dialysis in the computation of organ survival may be valid for several reasons. Our analysis of the reported causes of death revealed that 38% were related to infection. If we presuppose that all infectious deaths were related to immunosuppression to overcome HLA incompatibility, and the remaining 62% were not related immunologically (non-HLA related deaths), then the inclusion of these deaths would have resulted in a bias toward a lower percent survival. If the primary focus of a transplant study is the relationship of HLA matching to graft survival, exclusion of these deaths may be valid. Admittedly, inclusion of patient deaths in actuarial survival computations are of great practical importance to advise a patient as to his possible fate after transplantation.

For cadaver donor transplants with a positive crossmatch, improved survival with better HLA matching was indicated. These crossmatch positive "presensitized" patients may have selected out more compatible transplants with better matching outside the HLA A and B loci, that is, "D" (MLC negative) or

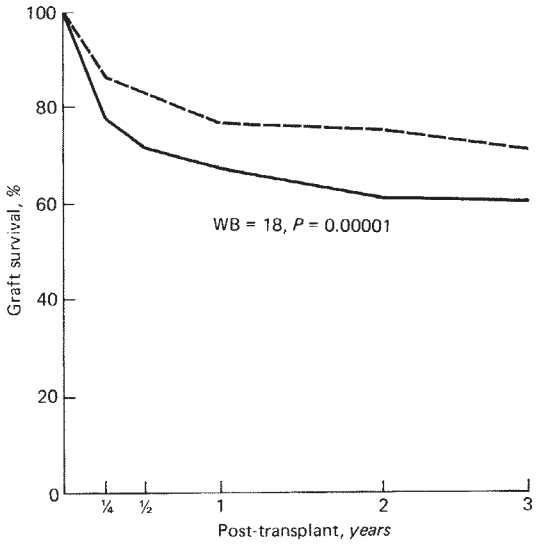

Fig. 2. *Actuarial percent survival for living related donor organ group.* Patients who died before redialysis were excluded. $N = 928$ (surviving organs = 701; organ failure = 227). The *solid line* represents the low match group (0, 1, 2 matches). The *broken line* represents the high match group (3, 4 matches).

DR loci. Several studies have noted this enhanced effect of HLA matching in presensitized patients [13].

The importance of the "D" locus can be seen in cadaver and live related donor transplants since they both showed nearly a 30% difference in graft survival at 1 year between high and low match groups. As mentioned, the reliability of MLC data may be considered suspect. Nevertheless, as in this study, improvement in cadaver donor graft survival with low mixed lymphocyte culture reaction was found in one previously reported study by Cockrum et al [14]. In their study, out of 59 cadaveric graft recipients, 37 had low MLC's. Thus, the ratio of low MLC to high MLC in their study was 1.6 to 1 for these cadaver donor recipients. In this study, a similar ratio, 1.3 to 1 of negative to positive MLC reactions was found. Whether the negative MLC in this study corresponds quantitatively to the low MLC of the previously reported study by Cockrum et al [14] cannot be determined. The results from both studies need to be verified by further evaluation of MLC reactions in cadaver donor recipient pairs. The improvement in graft survival, with negative (low) MLC reactions may be due to DR locus antigen matching in these MLC negative transplants, since the D and DR loci may be linked genetically [15]; or, DR antigens may be identical to the HLA D specificities [1]. For both cadaver and live related transplants with positive MLC reactions, the smaller percent survival in the high match groups relative to low match groups may indicate that D locus matching supercedes the effects of HLA A and B loci matching on graft organ survival. Unfortunately, the value of the MLC reaction in cadaver donor selection is negated by the fact that the results of the test usually cannot be obtained prior to the transplant.

The lack of statistically significant differences in organ survival in subgroups of cadaver and live related donors (Tables 6 and 7) may be due to their smaller sample size than the overall groups, or because of an actual disadvantage caused by the controlling factor with respect to organ survival. The trends toward improved survival with better HLA matching in cadaver with blood type O and female recipients of cadaver organs are opposite of previously reported results [5]. Blood type O recipients receive transplants from only other blood type O donors and this may cause an advantage relative to the non-O blood group recipients. Female recipients may be "presensitized" after pregnancy and "select out" better matched kidneys.

The information on the transfusion status, receipt of antilymphocyte serum, pretransplant splenectomy, and the general medical condition of the patients in the low versus high match groups were not available in the ESRD MIS.

In conclusion, despite the substantial limitations of the ESRD MIS data on which this study was based, this study analyzes and presents, to our knowledge, the first United States national renal transplant experience since the 13th Report of the Human Renal Transplant Registry by ACS in 1977. Because of the data problems, definitive statements concerning transplant organ survival cannot be made. Nevertheless, the statistically significant differences in organ survival between high (3 or 4 HLA A and B loci matches) versus low (0, 1, or 2 HLA A and B loci matches) match for live related and cadaver donor groups appear to be valid. Thus, the results of this study do not point to a need to change in the current practice of utilizing HLA matching in renal transplantation. On the other hand, one can argue that for cadaver donor transplants the 5% ($P < 0.03$) difference in 1-year survival comparing high versus low match groups may not justify delaying transplantation of a cadaver donor organ until a "high" match recipient can be found.

The difference in survival indicated in this study between high and low HLA A and B loci match groups was more pronounced in those cadaver and living related donor transplant recipients who were MLC negative and in those cadaver donor transplant recipients with cross-match positive reactions. This difference may be related to matching in the DR locus and possibly other histocompatibility factors.

Comparing the results based on the ESRD MIS data to the results of previously reported primarily United States transplant studies, the proportions of nonwhite renal transplant recipients and cadaver donor recipients have both increased between 1971 to 1980 by almost 10%. This may be explained by the predominance of cadaver donor transplants in nonwhite recipients.

Comparing the methodology of this study to several other major retrospective studies: This study *(1)* is based exclusively on the United States national transplant population, *(2)* is based on the interpretation of whole survival curves for the study period as well as one point in time, and *(3)* excludes death prior to redialysis in assessing organ failure. These issues should be considered in future studies.

To adequately address the preliminary findings of this study and those reported by the previous studies of United States renal transplants, a substantial modification of the ESRD MIS is necessary. This modification effort should include the expansion of the range of information items to be collected and devise methods to improve the compliance of data reporting, reliability, and uniformity.

Table 7. Acturial percent survival—living related donor organs

Controlling factors	Survival time for low and high matches					N^b	Wilcoxon/Breslow test statistic[a]	P value[a,b]
	3 Months	6 Months	1 Year	2 Years	3 Years			
Overall								
% Survival for low match	82.2	73.9	70.7	64.4	64.4	928	18.00	0.001
% Survival for high match	88.6	85.7	82.0	79.4	76.2			
Crossmatch (−)								
% Survival for low match	82.3	73.9	70.2	64.3	64.3	916	18.19	0.001
% Survival for high match	88.7	85.7	82.2	79.5	76.2			
Crossmatch (+)								
% Survival for low match	—	—	—	—	—	—	—	—
% Survival for high match	—	—	—	—	—	—	—	—
MLC (−)								
% Survival for low match	82.9	73.3	70.4	63.7	63.7	376	8.37	0.005
% Survival for high match	88.5	86.7	84.2	80.3	76.4			
MLC (+)								
% Survival for low match	81.0	77.1	74.1	68.7	65.7	102	0.38	—
% Survival for high match	82.2	67.3	67.3	67.3	—			
Recipient blood type (type O)								
% Survival for low match	81.4	74.2	71.1	64.9	64.9	402	5.77	0.01
% Survival for high match	86.8	84.1	80.1	80.1	80.1			
Recipient blood type (non O)								
% Survival for low match	82.3	73.2	67.8	64.3	64.9	480	11.59	0.001
% Survival for high match	89.8	86.8	83.2	78.8	73.3			
Recipient race (white)								
% Survival for low match	80.5	68.0	68.0	58.2	58.2	240	3.02	0.04
% Survival for high match	85.3	81.8	77.6	66.8	61.0			
Recipient race (nonwhite)								
% Survival for low match	87.5	87.5	87.5	87.5	87.5	33	0.03	0.43
% Survival for high match	94.1	87.6	77.9	77.9	—			

Abbreviation: MLC, mixed lymphocyte culture.

[a] Wilcoxon-Breslow (WB) test statistics analyze the statistical significance concerning the relative differences between curves; a one-tail P value is reported for the statistical significance of the given WB. A WB test value greater than 3.8 and P value for each of less than 0.05 is considered statistically significant. Subgroup numbers are smaller than group numbers since they include data for the controlling factors as well as for a HLA match.

[b] Both N and P values apply to high and low matches.

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